Auto-Gopher - a wire-line rotary-hammer ultrasonic drill

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ABSTRACT

Developing technologies that would enable NASA to sample rock, soil, and ice by coring, drilling or abrading at a significant depth is of great importance for a large number of in-situ exploration missions as well as for earth applications. Proven techniques to sample Mars subsurface will be critical for future NASA astrobiology missions that will search for records of past and present life on the planet, as well as the search of water and other resources. A deep corer, called Auto-Gopher, is currently being developed as a joint effort of the JPL's NDEAA laboratory and Honeybee Robotics Corp. The Auto-Gopher is a wire-line rotary- hammer drill that combines rock breaking by hammering using an ultrasonic actuator and cuttings removal by rotating a fluted bit. The hammering mechanism is based on the Ultrasonic/Sonic Drill/Corer (USDC) that has been developed as an adaptable tool for many of drilling and coring applications. The USDC uses an intermediate free-flying mass to transform the high frequency vibrations of the horn tip into a sonic hammering of a drill bit. The USDC concept was used in a previous task to develop an Ultrasonic/Sonic Ice Gopher. The lessons learned from testing the ice gopher were implemented into the design of the Auto-Gopher by inducing a rotary motion onto the fluted coring bit. A wire-line version of such a system would allow penetration of significant depth without a large increase in mass. A laboratory version of the corer was developed in the NDEAA lab to determine the design and drive parameters of the integrated system. The design configuration lab version of the design and fabrication and preliminary testing results are presented in this paper.

KEYWORD: Piezoelectric, piezoelectric horn transducers, Life detection, planetary sampling, corer, wireline drill.

1. INTRODUCTION

The acquisition of rock and soil sample plays an important role in NASA's space explorations missions. Tools capable of coring, drilling, and abrading are necessary for such activities. Due to the energy and mass limitations of such missions, the large axial forces and high power consumption of conventional drills are extremely undesirable. In addition, conventional drills operate at greater depth by adding new drill segments on top. This could possibly increase the mass, volume, and complexity of the system. The NDEAA team and Cybersonics address many of these issues with the Ultrasonic/Sonic Drill/Corer (USDC) [1]. Inside the USDC, a piezoelectric actuator generates vibration that propagates through a horn, which then impacts a free-flying mass. The mass then impacts a drill bit introducing stress pulses onto the drill bit, thus impacting and fracturing the rock as the rock's ultimate strain is exceeded. The USDC's key features include lightweight, low axial forces, and the ability to act also as an on-site analyzer [3]. Furthermore, the wire-line drill design of the USDC allows it to operate at depths larger than the drill length without additional drill segments. The focus of this research task is on the development of Auto-Gopher, a rotary-drill design based on the USDC. In addition to existing features of the USDC, the Auto-Gopher incorporates a rotary actuation (Figure 1). As the USDC drills and cores, it will need to periodically be removed from the produced borehole to empty an internal chamber where cuttings accumulate. This gives it the nickname Auto-Gopher.

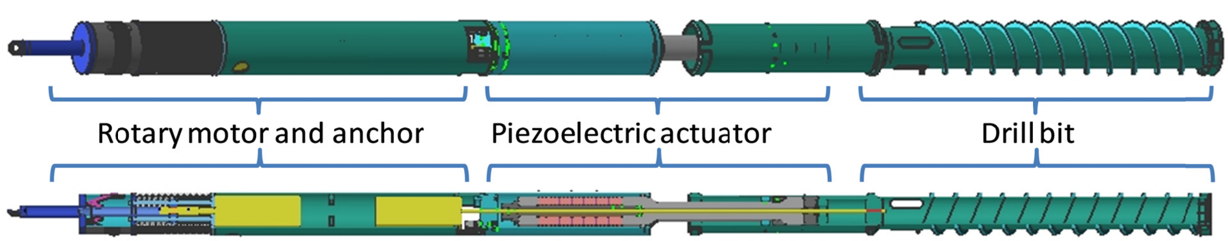

Figure 1 Auto-Gopher solid model and cross section